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MAGMATISM, METAMORPHISM AND METALLOGENY OF THE VARDAR ZONE AND SERBO-MACEDONIAN MASSIF

PLATE TECTONIC ASPECTS OF ALPINE METALLOGENY IN THE CARPATHO-BALKAN REGION

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Metamorphic Evolution and P - T Conditions of Crystallization of Eclogite - Amphibolites in the Buchim Block, Serbo - Macedonian Massif, Macedonia

[1]Mircovski, V., [2]Korikovski, S., [1]Stojanov, R., [1]Boev, B.

[1]Faculty od Mining and Geology, Goce Delcev 89, 92000 Stip, Republic of Macedonia.
[2]Institute of Geology of Ore Deposites, Petrography, Mineralogy and Geochemistry, Russian Academy of Sciences, Staromonetny 35, 109017 Moscow, Russia.

Abstract

Microstructural characteristics and mineral assemblage indicate prograde and retrograde stage in the metamorphic evolution of eclogite - amphibolites of the Buchim block.

Based on Fe/Mg distribution between clinopyroxene and garnet and the content of Jd component in clinopyroxene, maximum T of 570 to 650 °C and P of 12 - 12.5 Kbar were determined for prograde eclogitic stage. The increase of the content of anorthitic component in plagioclase of reaction symplectites as well as progressive zoning in garnets surrounded by hornblende - plagioclase symplectite indicates an increase of T in the initial stage of uplift, and later T get "normal" retrograde trend and decrease due to uplift movement.

P - T condition determined that maximum depth at which metamor-phose took place ranges from 47 km (P = 12 - 12.5 Kbar) that coincides to temperature gradient to 14°C/km.

Key Words: eclogite - amphibolites, omphacite, garnet, plagioclase, thermo-metry, metamorphism.

Introduction

Eclogite - amphibolites were found in the Precambrian metamorphic complex in the northern part of the Buchim block of the Serbo - Macedonian Massif (Ivanova, 1984, Mircovski, 1990). The rocks were encountered as small conformable layers ranging from 0.5 to 10 m in thickness and trending for a few hundred meters to a few kilometers in a sequence gneisses, garnet para and orthoamphibolites and garnet - clino-pyroxene - amphibolites and gneisses.

Both the eclogite - amphibolites and their host rocks reveal traces of prograde and retrograde metamorphism.

Metamorphism and P - T Evolution

Based on microtextural features and chemical composition of mineral assemblage such as clinopyroxene [1+2], garnet, hornblende [1+2] clinocoizite, quartz, rutile and titanomagnetite in the metamorphic evolution of eclogite - amphibolites, garnet - clinopiroxene amphibolites and their host rocks from the Buchim block two stages are distinguished: prograde and retrograde.

Prograde stage. The primary minerals of the eclogite - amphibolites are: omphacite - augite clinopyroxene, garnet, brownish green hornblende, quartz and rutile, along with subordinate sodic plagioclase, clinozoisite, and titanomagnetite, Judging by the geochemistry of the rocks, they are low - potassic weakly alkaline N - and T - MORB (data of G. S. Zakriadze). The texture of the rocks is granoblastic, porfiroblastic, poikiloblastic or blastomylonitic, with absolutely aquilibrium relationships between the minerals. It should be stressed that equilibrium relationships were also observed between rounded individual grains of primary oligoclase, omphacite, and garnet. Mineralogically, the eclogite - amphibolites affiliate with the same group as the Grt - Cpx - Hbl and Grt - Hbl - Pl metabasites and gneisses and differ only by the relative amounts of certain minerals, parti-cularly, primary Pl. Because of this, we will discuss the mineral assemblages of all these rocks together.

The primary clinopyroxene develops as prismatic grains with variable contents of the Jd component: from 5 - 34 % in the melanocratic eclogite - amphibolites and from 0-10 % in the

meso and leucocratic clino-pyroxene - garnet amphibolites and geisses (Fig.1). The garnet of these rocks usually has a clear - cut prograde zoning (Fig.2) with maximum Prp contents in the margins (up to 34 %), the Cpx - bearing amphibolites some-times contain Grt with Grs contents retrogradely increasing rimward.

The brown - green hornblende belongs to the pargasite - hastingsite group and contains 0.8 - 2.2 wt % TiO_2 and up to 3.3 wt % Na_2O. The primary plagioclase contains 12 - 27 % An in the eclogite - amphibolites and up to 51 % this component in the Cpx - Grt amphibolites and gneisses.

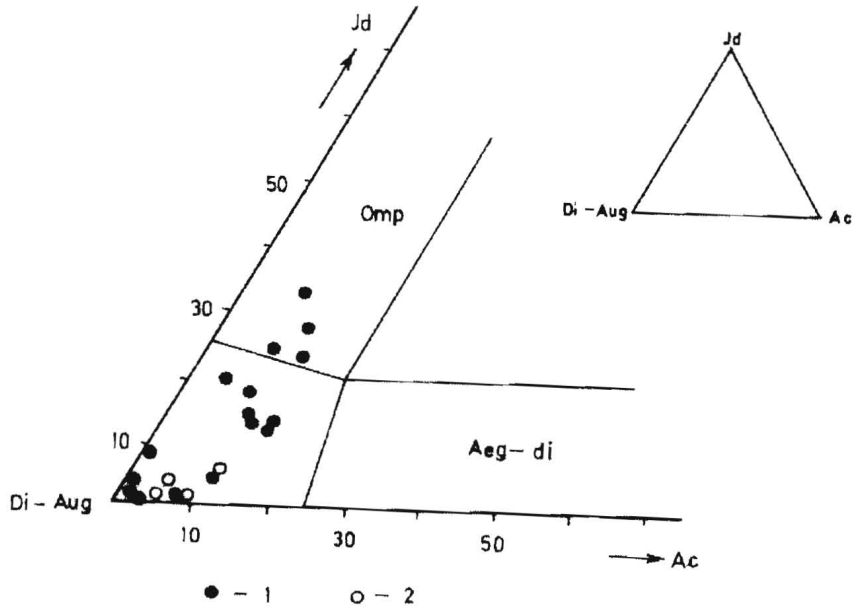

Fig.1. Composition of the primary|Cpx^1) from eclogite - amphibolite and Cpx - Grt - amphibolites, and secondary Cpx^2 from the Cpx^2 - Pl^2 symplectites around omphacites. Essene & Fyfe (1967). ● -Primary clinopyroxene, O - Secondary clinopyroxene.

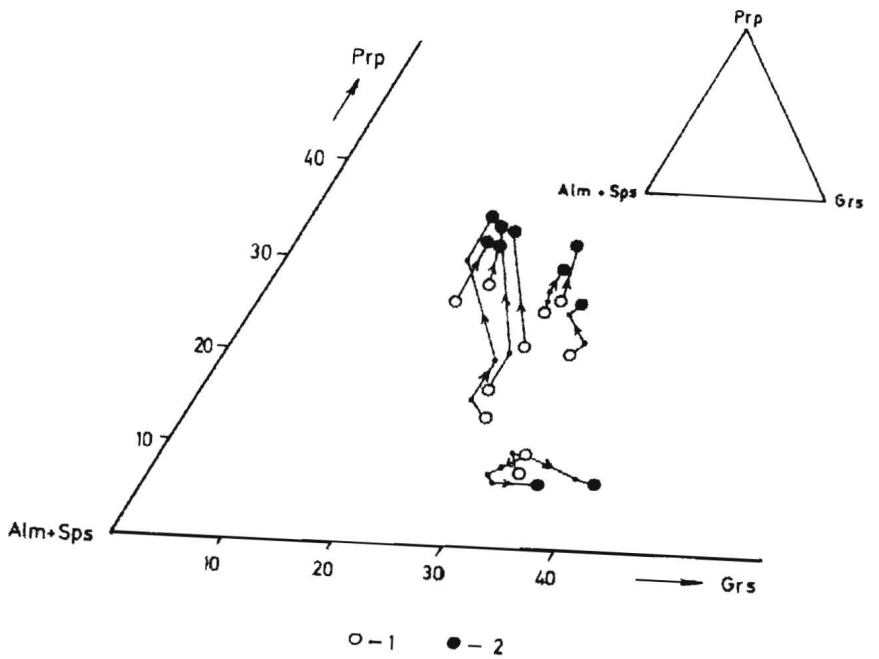

Fig.2. Zoning of garnets on the Prp - (Alm + Sps) - Grs plot: O - core,● - rim.

The metabasites of all types reveal a clear correlation of their mineral assemblages and the compo-sition of minerals with the bulk - rock chemistry. The corrrelations detected between the contents of Na, and Ca, and (Mg + Fe) indicate that the more sodic rocks contain coexisting more sodic clinopyroxene and plagioclase (Fig.3). Conversely, the more calcic rocks (these are usually Cpx - Grt amphibolites) bear clinopyroxene almost without jadeite, and their plagioclase is labradorite 50 - 51 % An (Fig.4), in which the compositions of the coexisting primary clinopyroxene, Ca amphibole, and garnet are presented, obviously indicate that the crystallization and coexistence of various types of metabasites in the matamorphic complex of the Buchim block were controlled by the bulk - rock compositions and not only by the grade of retrograde processes. For example, the assemblage Grt + Cpx^1 (1) (eclogite) devoloped in Ca - and Al - richer rocks, the assemblage Cpx^1 + Hbl^1 (2) (Cpx amphibolite) occurs in the Mg - and Fe - rich rocks, and Hbl^1 + Grt (3) (Grt amphibolite) is contained in relatively Ca - poor rocks. The rocks with intermediate Ca, Al, an Mg, Fe ratios are Cpx - Grt - Grt - eclogite - amphibolites, which are the most typical of the Buchim block.

As Grt - Cpx thermometry of the eclogite indicates that progade - stage equilibria were attained at a maximum temperature of 570-650 °C (Schleistedt, 1986) and a pressure of 12 - 12.5 Kbar, which correspond to the stability of clinopyroxene with 34 % Jd in associatioh with acid plagioclase and quartz at T = 650 °C (Holland,1980).

These P - T esitimates correspond to the field of relatively "shallow - depth" crustal eclogite of the plagioclase depth facies, in which Pl - bearing eclogite - amphibolites can form (Carswell, 1990) simultaneouslu (depending on the composition of rocks) with Grt amphibolites and other metabasite with Pl. The respective metapelites contain stable staurolite, kyanite, muskovite - phengite and plagioclase.

The Sm - Nd age of the prograde metamorphism , determined on minerals of the eclogite - amphibolites), is 260±49 Ma Permian (S.F. Karpenko, Vernadsky Institute of geochemistry, Moscow, personal communication).

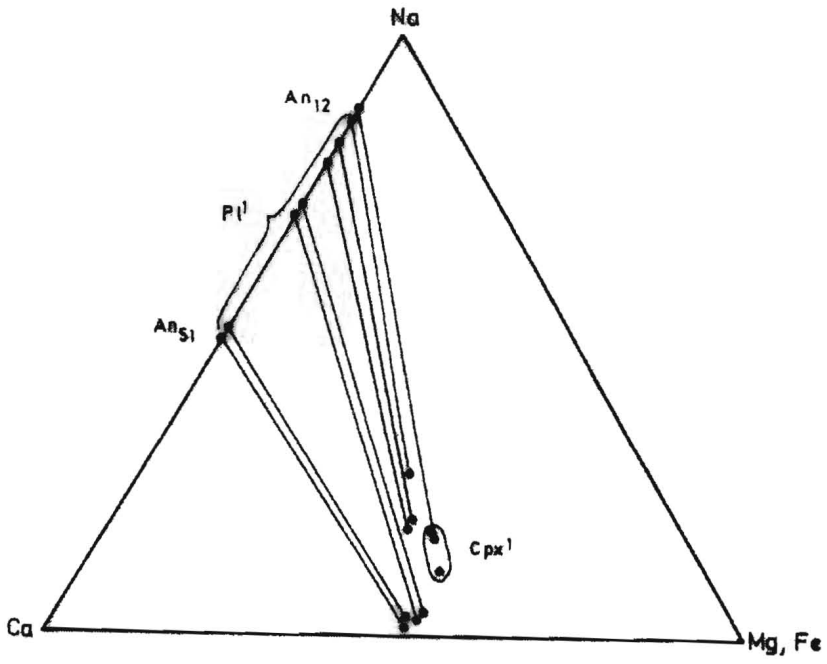

Fig.3. Correlation of compositions of the coexisted primary Cpx and Pl^1 in eclogite - amphibolites and Cpx - Grt - amphibolites on the Na - Ca - (Mg, Fe) plot.

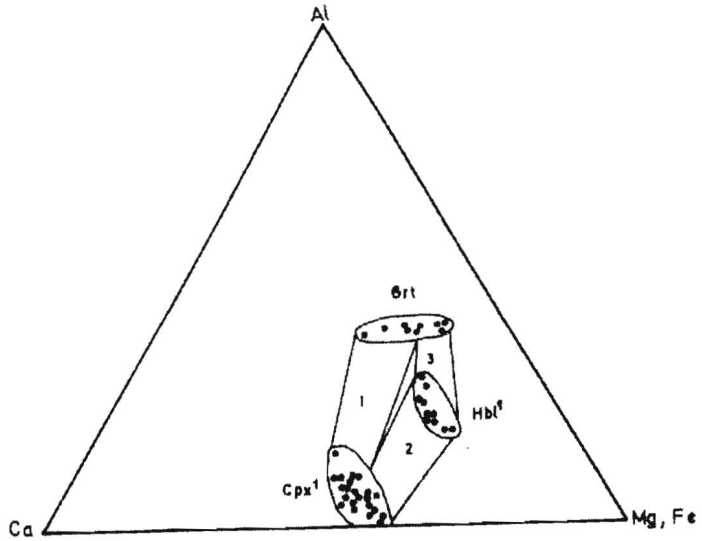

Fig.4. Phase equilibria of the coexisted Grt, Primary Cpx^1 and Hbl^1 metabasites of the Buchim blok (see the text).

Retrograde stage. This stage was responsible for the development of very micrograined secondary clinopyroxene - oligoclase symplectite around the primary omphacite of the eclogite - amphibolites. The Jd content of the secondary Cpx^2 does not exceed 6 % (Fig. 1) and Pl^2 bears no more than 25 - 32 % anorthite. Fine - grained Hbl^2 - Pl^2 symplectite developed between the primary garnet and omphacite (or primary Hbl^1). The amphibole in symplectites is bluish green pargasite - hastingsite with very low TiO_2 contents (0.1 - 0.4 wt %), plagioclase inclusions are labradorite - bytownite (60 - 73 % An). Such a strong increase in the Ca content of the plagioclase in reaction symplectites of the eclogite - amphibolites (as compared to that of the primary oligoclase) seems to be indicative of the fact that the early retrograde uplift was attended by an inertial temperature increase, which resulted in such unusual compositions of the symplectites. The evidance in favour of that are a preservation of the prograde zoning of garnets surrounded by Hbl^2 - Pl^2 symplectites. Later, as the uplift progressed, the secondary blue - green amphibole gave way to colorless (actinolite - like) amphibole, which marks the transition to a "normal" retrograde trend. Simultaneouslu, somewhat similar retrograd alterations occurred in the host rocks: their garnets and clinopyroxenes are replaced by amphibole, biotite, and epidote (in the metabasites), and the garnets and biotites are replaced by muscovite and chlorite (in the gneisses).

Conclusion

The facts presented above led us to conclude that all rocks of the Buchim block, including the eclogite - amphibolites, underwent a similar metamorphic evolution: (1) initial (during the late hercynian collision) deep descent to depths as low as 47 km (12.5 Kbar) at a temperature of no higher than 650 °C, which correspond to a gradient of 14 °C/km, and (2) subsequent uplift, which was first accompained by a temperature increase and then - by its decrease.

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